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Research article

The Effects of Computerized Neuromuscular Control Training on Athlete's Dynamic Postural Control Ability

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Abstract

Balance is an important element of almost all sports activities and activity daily living (ADL). Balance can be measured based on individual postural control which consisted of static, semi-dynamic and dynamic. These aspects were controlled by neuromuscular and reduction in the neuromuscular ability due to injury such as patellofemoral pain syndrome (PFPS) may alter the postural control ability. The aim of this study was to investigate the effects of neuromuscular control training on athletes with PFPS. In this study, there were 27 athletes with PFPS (male = 22, female = 5; mean age = 14.59 ± 1.28 years, height = 161.96 ± 7.85 cm, weight = 54.93 ± 11.42 kg and Body Mass Index (BMI = 20.65 ± 2.20) voluntarily took part in 8-week of computerized neuromuscular control training (CNCT) program. The Y-Balance Test was used for assessment of athlete's dynamic postural control (DPC). A doubly multivariate analysis of variance was performed on two measures of the test (pre and post-test) over three (3) dynamic postural control (DPC) characteristics between groups. This analysis was performed in order to identify the interaction and main effects of the intervention (CNCT) to participant's dynamic postural control (DPC). An 8-week of computerized neuromuscular control training (CNCT) program resulted significant changes in all aspects of dynamic postural control (DPC). It showed that CNCT program significantly enhanced athlete with PFPS's DPC ability in terms of anterior ($F(1,25)$ = 14.037, p = .001, ή = .260), posteriolateral direction ($F(1,25)$ = 13.774, p =.001, ή =.355) and posteriomedial direction ($F(1,25)$ = 11.318, p =.002, ή =.312). This study suggested the physician and coaches should emphasize more on neuromuscular training for athlete's with PFPS since the PFPS may reduce the athlete's performance especially in sports that require dynamic postural control.

Key words: Neuromuscular training, young athlete

Introduction

Balance is an important element of almost all sports activities and activity daily living (ADL). Balance can be measured based on individual postural control which consisted of static, semi-dynamic and dynamic. The maintenance of this complex process depends on the vestibular system, age, pain, vision, body shape, visual-spatial perception, tactile input, agility, proprioception and the musculoskeletal and neuromuscular system (Jones & Barker, 2000). These aspects were controlled by neuromuscular and reduction in the neuromuscular ability due to injury such as patellofemoral pain syndrome (PFPS) may result in imbalance. For individual who experienced patellofemoral pain syndrome (PFPS) or usually referred as runner's knee the symptoms may cause 74% of them to limit sport activities or lead to sports cessation (Blond & Hansen, 1998). The symptoms of PFPS are generally due to the loading on the knee during flexed position such as walking up and down stairs, squatting or rising from a seated position and the patients generally complain of restriction of gait (Powers, 2000). The symptoms also occur when the patients sit for a long time with the knees flexed (McConnell, 1986). Individuals with PFPS will try to reduce the irritation of the symptoms by adjusting their gait and other activities by decreasing their patellafemoral reaction joint force (PFJRF). Common compensation movements includes decrease knee flexion during stance phase of gait, reduce walking velocity and leaning the trunk anteriorly during stair ambulations (Salsich et al., 2002). All of these gait adjustment might change their postural balance thus increase more serious knee injuries.

To date, a number of approaches to physiotherapy management for PFPS have been proposed to alleviate pain through restoration of patellar alignment via use of interventions like muscle strengthening exercises, stretching, patellar taping, bracing, orthoses, manual therapy, electric stimulation and EMG biofeedback (Crossley et al., 2002). However, studies showed that approximately 25% of patients continue to have pain and dysfunction for more than one year after physiotherapy has been completed (Piva et al., 2009).

It seems that restoring patellar alignment is still not enough for a functional recovery among PFPS patients because neuromuscular controlling mechanism is required during daily living and sports specific activities (Williams et al., 2001). Therefore, both mechanical stability and neuromuscular control are important for long-term functional outcome, and both aspects must be considered in the design of PFPS rehabilitation program.

Based on mechanical stability and neuromuscular control theories and measures relevant construct described above, the study sought to investigate the dynamic postural control (DPC) aspect of athlete with PFPS and the effectiveness of an intervention program (neuromuscular control training) towards intervention group.

Methods

Participants

Participants were recruited using via contact details given by physiotherapist in Tunku Mahkota Ismail Sports School, Kota Tinggi, Johor, Malaysia The inclusion criteria were set as follows: age within the range of 13 to 19 years old, participated in the inter-state level for at least one year, experienced anterior knee pain surrounding the patella or in the sub-patella region for more than four weeks, insidious onset of symptoms unrelated to a traumatic event, pain from at least two of the following activities commonly associated with PFPS: prolonged sitting, ascending or descending stairs, squatting, kneeling, running, hopping or jumping (Crossley et al., 2002) and identified as PFPS patient by qualified physician. Oral and written explanations of the study were offered to the participants. Participants were excluded if they had one of the following exclusion criteria: chondromalcia patella (degeneration or damage of the patellar cartilage based on Scuderi & Tria (2010), pain due to palpation along the quadriceps tendon or patellar ligament, medial plica snapping sensation, signs and symptoms of meniscal or articular cartilage pathology, knee joint effusion, history of patellar subluxation or dislocation, history of osteoarthritis, history of neurological impairment, ligament laxity, history of Osgood-Schlatters and history of Sinding-Larsen-Johanson syndrome. Based on (Swanson, 2009) the patients who suffered from any of the followings in the area of joint; tumors, bone infections, traumatic injuries or metabolic disorders are unable to be adjusted if they were given the treatment of PFPS.

Participants Randomization

Randomization via computer-generated random numbers was performed in blocks of two Participants stratified based on first sign up for participants list. There were 27 participants and they were randomly assigned to the intervention group (n = 14) or the control group (n = 13).

Intervention

The intervention group went through normal training routine from their coach and 16 sessions of one hour of computerized neuromuscular control training program within eight weeks. The control group did not receive any intervention but were simply instructed to spend their normal training routine from coach during the intervention phase. In order to avoid contamination during the intervention period, the neuromuscular control training location was set at a place where the participants in the control group were not usually visit when the training session was on.

Warm-up and Stretching

Before training, participants participated in warm-up and stretching exercise consisting of 10 minutes walking on treadmill and dynamic stretching on calf, hips and quadriceps such as kick leg side, kick leg behind, mini squat, rise up toes and heels. These dynamic stretching exercises were performed for three sets with eight repetitions each. These warm-up and stretching exercises were targeted on lower leg muscles.

Computerised Neuromuscular Control Training (CNCT) Program

Computerized neuromuscular control training program consisted of preprogrammed training mode (Chase Trainer-CT) which required participant to stand with both foot on Balance Trainer platform (BT3, HurLab, Tampere, Finland) and shifting their weight anterior-posterior and lateral-medial direction guided by diagram in computer screen (Figure 1). In this training mode, participant was instructed to maintain their shifting position (red line) in the blue circle as it moved and needed to complete a sequence of nine (9) conditions as programmed by the researcher. Each condition required the participant to shift their weight for 60 seconds. The score was displayed on the screen based on the percentage of time participant spend on the blue area. If the participant could not reach the minimum 70 percent of score, the training was terminated in order to prevent more serious injuries.

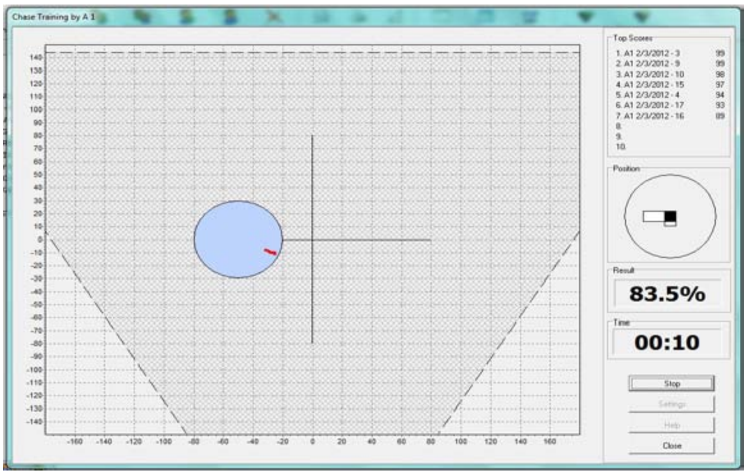


Figure 1. Diagram of screen for chase trainer in balance trainer

Testing Procedures and Protocol

The experimental period consisted of two blocks of testing over eight weeks, with at least one familiarization session. Participants in intervention group underwent their daily training routine and computerized neuromuscular control training after the familiarization session meanwhile participant in control group underwent only their daily training routine. Measurement (post-test) were taken prior to eight weeks of first measurement (pretest) were taken.

Dynamic Postural Control (DPC) using Y-Balance Test

The pre and post of standardized measurement protocol of Dynamic Postural Control (DPC) was proposed using Y-Balance Test (Figure 2). The participants were requested to perform one leg stand (injured leg) in the middle of the testing grid and reach as far as possible with another leg (non-injured leg) in three directions on the grid (anterior, posteriomedial and posteriolateral). These directions had been considered sensitive to functional deficits related to lower limb injury with intraclass coefficients of correlation (ICC) between .88 to .99 (Plisky et al., 2009).

Prior to testing, participants were given two practices trials in three reach directions. After the participants completed the practice trial in all three directions, the participants were given one minute rest before the formal testing begins. During the formal testing, participants need to perform three set of trials in each of the three reaching directions at random order. Participants need to stand on one leg (injured leg) in the center of the grid with the most distal aspect of the toe at the beginning of the line. Participants were encouraged by the researcher to reach as far as possible with another leg (non-injured leg), lightly touch their toe on the line, and return their foot back to the stance leg.

They were required to keep their hands on their hips throughout the entire test. The participants need to repeat the trial if they failed to maintain a unilateral stance, lifted or moved the stance foot, touched down with the reach foot, or failed to return the foot to the starting position.

The neuromuscular control training session or testing were rescheduled to more appropriate time. The reach distance was measured and recorded by the researcher using measurement tape. The average of the reach distances were recorded in millimeters and normalized to leg length This was done by dividing the reach distance by the participant's leg length and converting to a percentage for each of the three reach directions.

Statistical Analysis

The descriptive data are presented as means and standard deviation. Prior to neuromuscular training, a MANOVA was used to determine whether differences existed between intervention and control groups. For all procedures, significance was accepted at the alpha level of .05.

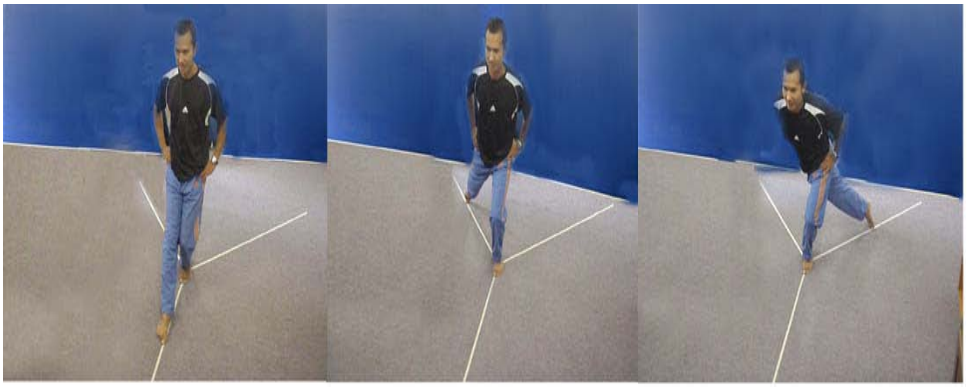
Results

Study Population

Our initial pool of study participants comprised 30 athletes who experienced PFPS from Tengku Mahkota Ismail Sports School, Kota Tinggi, Johor, Malaysia. However two (2) refused to participate and one (1) did not meet the inclusion criteria. The remaining 27 athletes (male = 22, female = 5; mean age = 14.59 ± 1.28 years, height = 161.96 ± 7.85 cm, weight = 54.93 ± 11.42 kg and Body Mass Index (BMI) = 20.65 ± 2.20) agreed to participate in the study and provided written consent.

Adherence to the Study Protocol

During the 8-week intervention phase, 16 exercise sessions were scheduled and all took place. The intervention group participants attended an average of 15 sessions and had an overall attendance rate of 93% over the 8 weeks. No injuries problems occur during the sessions except complaining from subject regarding tiredness due to hard training from their coach.



(a) (b) (c)

Figure 2. Direction of Y-balance test: (a) anterior (b) posteriomedial (c) posteriolateral

ted the study were summarizes in Table 1. No significant differences between the intervention and control groups were observed in all variables except in dynamic postural control for posteriomedial direction.

Effects of Intervention

After 8-weeks of intervention phase, the data of dynamic postural control (DPC) were analyzed using MANOVA in order to determine the effect interaction and main effects) of the intervention (CNCT) on participant's dynamic postural control. Due to unequal number of participants between the groups, only Pillai's Trace analysis were used (Tabachnick & Fidell, 2001).

Using the Pillai's Trace criteria, the between group interactions, deviated significantly from parallelism at $F(3,23) = 90.349$, $p < .001$, ή = .922. This significant was also seen within participants between trial (pre and post) at $F(3,23) = 27.098$, $p < .001$, ή =.779. The groups by test interaction (deviation from parallelism) also was strong and statistically reliable with multivariate $F(3,23) = 11.950$, $p < .001$, ή = .609. This indicated the interaction between the intervention (CNCT) effects were statically significant within and between groups.

Table 1. *Baseline Characteristic (Mean ± SD)*

Variable	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	***p***
Age (years)	14.93 ± 1.33	14.23 ± 1.17	0.161
Height (cm)	163.93 ± 4.86	159.85 ± 12.74	0.275
Weight (kg)	55.85 ± 6.78	53.92 ± 15.19	0.669
Body Mass Index	20.70 ± 1.57	20.59 ± 2.80	0.893
Dynamic Postural Control			
Anterior	90.82 ±8.02	84.41 ± 15.51	0.185
Posteriomedial	97.20 ± 26.08	46.19 ± 441	0.000*
Posterolateral	59.64 ±11.54	70.11 ± 12.43	0.035

Note. *Significant at p<0.05 level.

The main effects of computerized neuromuscular control training (CNCT) on athlete with patellafemoral pain syndrome (PFPS) were not significantly enhanced in all aspects of dynamic postural control. It shown in posteriomedial direction where the $F(1, 25) = 5.036$, $p = .034$, ή =.168. However for other aspects of tested dynamic postural control elements, it had shown a statistically significant.

Discussion and Conclusion

Individuals with PFPS generally have anterior knee pain that is exacerbated by knee loading activities. The results of this study provided evidence that partially supportive of the study hypothesis that dynamic postural control in all direction (anterior, posteriomedial and posteriolateral) in Y-balance test would increase after neuromuscular control training. The study revealed that neuromuscular control training did not have significance impact in posteriomedial direction.

This finding suggests that the individuas with PFPS may be able to modify redundant muscle coactivation during the Y-balance test. This was supported by previous studies where symptomatic leg muscle had shown compensatory strategy in terms of muscle activation compared to asymptomatic leg muscle in order to maintain postural stability (Nagai et al., 2012). By increased the activation of antagonist or synergist muscle such as hamstring, vastus medialis, individual with PFPS be able to reduce or lessen the pain around patella (Stendotter et al., 2008). Another explanation of why this result did not show any significant differences was limitation of this study which was baseline-matched control group. Since there was difference in posteriomedial direction between groups at baseline it influenced the outcomes. As supported by Assmann et al. (2000), if a baseline factor strongly influences outcome, a non-significant treatment imbalance may be important.

In conclusion, the intervention that been proposed (computerized neuromuscular control training using Chase Trainer in BT3) was effective and improved athlete with PFPS in other two aspects in dynamic postural control (anterior and posteriolateral). Based on this evidence, we recommend the use of this intervention for postural and neuromuscular control improvements. Given that these are desirable adaptations after injury or disease to prevent long-term functional restrictions; neuromuscular control training might be useful both in rehabilitation and for preventive purposes. Further research is needed to determine the efficacy and dose-response relationship of neuromuscular control training for functional performance improvements and postural control changes.

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